

GEOTECHNICAL ENGINEERS INC.

FINAL REPORT

EVALUATIONS AND COST ESTIMATES  
FOR  
PROPOSED INSTRUMENTATION AT  
BALL MOUNTAIN DAM  
JAMAICA, VERMONT

New England Division  
Corps of Engineers

September 24, 1985

Prepared for

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by

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Project 85681

  
Ronald C. Hirschfeld, P.E.  
President

from Electronic Distance Measuring Instruments (EDMI) will be attached to the survey monuments. Four survey pillars should be installed in the dam abutments to serve as stations for the EDM. Details of the survey pillars are shown in Fig. 5. First-order surveying is proposed and is estimated to yield accuracies of about 3-5 mm (0.01 to 0.015 ft).

Cost estimates are presented in Section 4 for installation of the instrumentation, monthly monitoring for a period of 1 year, and preparing two reports summarizing the monitoring results. The following table summarized the estimated costs:

	Estimated Costs			
	Installation	Monitoring	Reports	Total
Slope Inclinometers				
Drilling Contractor and Materials	\$104,000 to \$156,000			
A/E Observation Services	<u>29,000</u>	<u>\$33,000</u>	<u>\$12,000</u>	
Subtotal	\$133,000 to \$185,000	\$33,000	\$12,000	\$178,000 to \$230,000
Survey Monuments and Pillars				
Drilling Contractor and Materials	\$ 19,000			
Surveying Contractor	<u>11,000</u>	<u>\$155,000</u>	<u>\$ 9,000</u>	
Subtotal	<u>\$ 30,000</u>	<u>\$155,000</u>	<u>\$ 9,000</u>	<u>\$194,000</u>
TOTALS	\$163,000 to \$215,000	\$188,000	\$21,000	\$372,000 to \$424,000

We recommend that the dam sections at Stations 4+30, 5+95, and 7+80 be surveyed prior to installation of the inclinometers and survey monuments. The surveyed sections can be compared to the design slope geometry and can be used to help finalize the actual instrument locations.

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## EXECUTIVE SUMMARY

The purpose of this study was to evaluate and provide cost estimates for instrumentation proposed by the New England Division, Corps of Engineers (NED-CE) for monitoring embankment slope movements at Ball Mountain Dam, Jamaica, VT.

Ball Mountain Dam is an earthfill and rockfill dam with a maximum height of 265 ft and a length of 915 ft. The core of the dam is constructed of silty gravelly sand and the shells are rockfill. The downstream and upstream slopes are 1.75H:1V and 2H:1V, respectively.

A bulge in the downstream slope and settlement of the crest has been reported in previous NED-CE inspection reports. Geotechnical Engineers Inc. (GEI) made a site visit to observe the site conditions.

There is a bulge on the downstream slope about 175 ft downslope of the crest extending between the abutments at approximately constant elevation and profile. A trough in the embankment is located at the toe of the bulge paralleling the bulge and extending between the abutments. Several sections along the downstream side of the crest have settled relative to the upstream side. We understand that differential settlements of up to 2 ft have occurred since the dam was completed in 1961. The settled areas have been periodically repaired with backfill.

A plan and cross section of the dam with the locations of the NED-CE proposed instrumentation and GEI recommended modifications are shown in Figs. 2 and 3. The NED-CE proposed instrumentation consists of 6 slope inclinometers and 35 survey monuments on the downstream slope and the crest.

We recommend that the three slope inclinometers located near the crest be installed 10 ft downslope from the locations given by NED-CE. All slope inclinometers should extend to El. 910, as shown in Fig. 3. The inclinometer casing would be installed in a 5-in.-diameter borehole advanced by a downhole hammer technique and backfilled with coarse sand or peastone. An access road and wooden drilling platform will be required for each inclinometer location. Details for inclinometer casing installation are presented in Fig. 4 and Appendix A.

We recommend that four additional survey monuments be installed at the locations shown in Fig. 2. They would be located in the trough observed at the toe of the bulge. The recommended design for the survey monuments is shown in Fig. 5. Survey targets to be used as reflectors for light

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## 1. INTRODUCTION

### 1.1 Purpose

This report presents the results of our evaluations and cost estimates of the field instrumentation proposed by the New England Division, Corps of Engineers (NED-CE) to monitor embankment slope movements at Ball Mountain Dam in Jamaica, Vermont.

### 1.2 Scope

The scope of work performed for this study was:

- a. Review existing reports, data, construction plans, and construction photographs provided by the NED-CE pertinent to embankment slope movements.
- b. Make a site visit to observe site conditions, in particular a bulge on the downstream embankment slope and settlement of the downstream side of the crest. Observe instrumentation locations proposed by the NED-CE.
- c. Evaluate the NED-CE proposed methods of assessing the bulge in the downstream slope and the settlement of the downstream side of the crest.
- d. Evaluate the NED-CE proposed instrumentation, including method, location, and depth of instrument installations. Provide technical specifications for instrumentation.
- e. Provide cost estimates for instrument installations.
- f. Provide cost estimates for monthly field instrument data collection, preliminary (6 months) report, and final (1 year) report.

### 1.3 Authorization

This study was authorized by Lt. Col. Edward D. Hammond of the NED-CE in a letter dated July 24, 1985.

#### 1.4 Available Data

The following information was reviewed as part of this study:

- a. NED-CE Periodic Inspection Reports for Ball Mountain Dam dated March 1975, July 1979, and September 1984 and numbered 1, 2, and 3, respectively. These reports indicate the presence of a bulge in the downstream slope and settlement along the crest.
- b. A study entitled "Subsurface Shear Plane Investigation" by Eastern Geotechnical Associates for the NED-CE dated June 10, 1985. Shear planes were found in test pits excavated on the crest of the dam on May 7, 1985.

The following NED-CE construction plans and data were reviewed:

- c. Design drawings CT-1-4172 to 4176.
- d. Design Memorandum No. 1.
- e. Specifications for Construction of Dam and Appurtenant Structures.
- f. Logs of borrow test pits.
- g. Laboratory test results for earthfill.
- h. Photographs of various stages of construction.

#### 1.5 Personnel

The following personnel at Geotechnical Engineers Inc. were involved with the project site visit, evaluations and recommendations, and preparation of the report for this project:

Principal-in-Charge	Ronald C. Hirschfeld, P.E.
Project Manager	Stephen L. Whiteside, P.E.
Geotechnical Engineer	Michael A. McCaffrey

Boston Survey Consultants of Boston, MA provided us with consultation for the proposed surveying work.

The following drilling contractors provided information on drilling methods and costs:

Construction Drilling, North Adams, MA  
Franki Foundation Company, Boston, MA  
Terra Drilling, Framingham, MA

Guild Drilling Co. of East Providence, RI provided information on drilling methods but could not provide cost information due to their contractual relationship with the NED-CE.

## 2. SITE DESCRIPTION

### 2.1 Dam Description

Ball Mountain Dam is located on the West River in Jamaica, Vermont (see Fig. 1). It is a unit of the Connecticut River Basin flood control plan. The dam is located about 29 miles upstream of the confluence of the Connecticut and West Rivers at Brattleboro, Vermont. It is 9.5 miles upstream of the Townshend Flood Control Dam. Construction of the dam was completed in 1961.

A plan and cross section of the dam are shown in Figs. 2 and 3. The dam is a rockfill and earthfill embankment with a concrete spillway and a low-level outlet tunnel in the right abutment. The embankment is 915 ft long and has a maximum height of 265 ft. The dam crest elevation is 1052 ft Mean Sea Level (MSL) and the crest width is 20 ft. The downstream and upstream embankment slopes are 1.75H:1V and 2H:1V, respectively. The core of the dam is constructed of silty gravelly sand, and the shell is constructed of rockfill.

### 2.2 Site Visit

On July 29, 1985 Messrs. Whiteside and McCaffrey of Geotechnical Engineers Inc. (GEI) made a site visit at Ball Mountain Dam with Mr. Paul L'Heureux of the NED-CE. We observed the condition of the dam by walking the crest and embankments.

The reservoir water level at the time of the site visit was at the base of the outlet tower. Most of the upstream slope was exposed. The upstream and downstream shells are composed of rockfill with stones ranging in diameter from 1 in. to 4 ft, typically about 1.5 ft. The slopes are generally void of vegetation. The dam crest is composed of a gravel base road.

We observed the bulge in the downstream slope which has been reported in the previous NED-CE Inspection Reports. As shown in Fig. 2, the bulge occurs practically for the full length of the dam, and it is located about 175 ft downslope of the crest at approximately a constant elevation and profile. The distance from the head to the toe of the bulge is approximately 60 ft. A trough in the downstream embankment is located at the toe of the bulge paralleling the bulge and extending between the abutments. The distance from the head to the toe of the trough is approximately 40 ft. The difference in height between the crest of the bulge and the bottom of the trough is about 4 ft measured perpendicular to the plane of the embankment slope.

Several sections along the downstream side of the crest have settled relative to the upstream side. The downstream edge of the crest also appears to have moved downslope in these sections. We understand that differential settlements of up to 2 ft have occurred since the dam was completed. The settled areas have been periodically repaired with backfill.

Three existing NED-CE benchmarks on the crest centerline reportedly have not shown signs of settlement. There is no apparent settlement or movement of the upstream side of the crest. Thus the crest and slope movements are apparently limited to the downstream section.

We observed the locations of the NED-CE proposed instrumentation for monitoring embankment movements (Fig. 2). Discussions of the instrumentations are in Section 3, Appendix A, and Appendix B.

### 3. FIELD INSTRUMENTATION

#### 3.1 Introduction

We have reviewed the NED-CE proposed instrumentation for assessing the bulge in the downstream slope and settlement of the crest. The proposed instrumentation consists of six slope inclinometers and 35 survey monuments at locations shown in Fig. 2. In Sections 3.2 and 3.3, we present the results of our review and our recommendations for the type of instruments to be used and the method, location, and depth of instrument installations.

#### 3.2 Slope Inclinometers

As shown in Fig. 2, the NED-CE has proposed six slope inclinometer installations. The NED-CE proposed to install the casing for SI-1, SI-3, and SI-5 to El. 930 and SI-2, SI-4, and SI-6 to El. 910. A tilt bed drill rig was planned to be used for installation of the inclinometer casing. The rig would be winched down the slope by two bulldozers acting as deadmen.

The number of the NED-CE proposed slope inclinometers is suitable for monitoring embankment slope movements. The NED-CE proposed locations for SI-1, SI-3, and SI-5 are near the downstream edge of the dam crest where the crest settlement is occurring and thus may be near the upstream limit of a potential failure surface. In order to intersect the failure surface farther downslope, we recommend that inclinometers SI-1, SI-3, and SI-5 be relocated 10 ft downslope on the same station lines as shown in Fig. 2. We recommend that all inclinometers should extend from the embankment surface to El. 910.

The slope inclinometers should consist of 2.75-in.-I.D. ABS telescoping slope inclinometer casing and telescoping slope inclinometer couplings installed in a minimum 5-in.-diameter borehole. The annulus between the borehole and the casing should be filled with coarse sand or peastone. A 5-in.-diameter protective steel casing with locking cap should be installed as shown in Fig. 4. Other slope inclinometer installation details are shown in the figure. Specifications for the slope inclinometer materials and installation are provided in Appendix A.

Due to the nature of the rockfill, conventional wash boring drilling techniques are not practical for drilling the holes for the inclinometer. Based on our discussions with

drilling contractors, we feel that the down-hole hammer method of drilling should be the most feasible for advancing a vertical borehole into the rockfill for the slope inclinometers. It would require a drilling rig capable of down-hole rotary percussion drilling and the ability to advance casing down the borehole. The Odex™ system has these capabilities and was recommended by the four drilling contractors we contacted. The Odex™ system uses a pilot bit with an eccentric reamer that makes a hole slightly larger in diameter than the casing that is advanced behind the eccentric reamer. The reamer is driven outwards by rotation of the drill rods and is retracted by reversing the rotation. The casing is driven by the impact energy transmitted from a down-hole hammer to the casing. Compressed air would be used to power the down-hole hammer and flush the cuttings from the hole. Drilling foam may be required to flush the cuttings once the hole is drilled below a depth of about 50 ft.

The drilling contractors' estimated rate of drilling through the rockfill at Ball Mountain Dam ranged from about 30 to 100 ft for an 8-hr work day.

The drill rig would have to be winched down the slope from the crest using a deadman and hoist installed at the crest of the dam. The hoist would also be used to winch supplies up and down the slope. We anticipate that three gravel or crushed stone roads would have to be constructed down the embankment from the crest to the boreholes at Stations 4+30, 5+95, and 7+80 to make a smooth surface for winching the rig. The roads would be advanced with a bulldozer winched from a deadman and hoist.

The drill rig may require a level surface to drill from at each borehole location. We have not found a commercial driller that has a tilt bed rig that could be used for the work. As a result we anticipate that a wooden platform would be necessary at each borehole location. The platform would be constructed at the first borehole and then disassembled and moved to the other borehole locations in advance of the drill rig. A track-mounted rig with a tilting drilling boom may not require such a platform or may require a smaller platform than a trailer or truck-mounted rig.

### 3.3 Survey Monuments

As shown in Fig. 2, the NED-CE proposed 23 slope survey monuments and 12 crest survey monuments. It was proposed that the slope monuments would consist of a 5-ft-long, 1/2-in.-diameter reinforcing steel bar grouted in a 5-ft-deep hole jackhammered in the rockfill. The rod would have a 3-in.

stickup above the dam surface. The crest monuments would consist of a 5-ft-long, 1/2-in.-diameter reinforcing bar driven into the dam with a sledge hammer. The NED-CE proposed to cap both the slope and crest monument bars with a government supplied aluminum disk.

The locations of the NED-CE proposed survey monuments are appropriate for monitoring embankment slope movements. However, we recommend that four additional survey monuments be installed at the locations shown in Fig. 2. They are located in the trough area at the toe of the bulge, described in Section 2.2, where movements may be anticipated.

The basic design criteria for a permanent survey monument is that it must be durable and stable over an extended period of time. It must be durable in order to resist the effects of weather and surface conditions which can cause unpredictable local movement. The size and material used in the construction should be such that any movement observed is related to the movement of the embankment being monitored.

Based on the existing information on the past movements at Ball Mountain Dam, we estimate that the rate of movement could be less than 0.1 ft per year. We feel that the NED-CE proposed monument design may not provide the degree of accuracy required for monitoring small movements. As a result we recommend that the slope survey monuments be constructed according to the sketch shown in Fig. 5.

The slope survey monument should consist of a 2-in.-I.D. concrete filled metal pipe embedded and grouted at least 2 ft into a borehole in the rockfill and extend 2 ft above the dam surface. A #6 (3/4-in. diameter) steel rebar should be embedded in the center of the pipe and should extend 5 ft below the dam surface. Target pedestals should be permanently installed in the top of the survey monument. A standard Wild target would be attached to the target pedestal each time the monument is surveyed. Horizontal and vertical movements will be measured.

The crest monuments should be similar to the slope monuments except that the 2-in. pipe would be installed flush to the ground surface and covered with a protective cap. The top of the pipe would have a threaded connection grouted into the pipe to allow a target pedestal to be screwed onto the monument during each survey.

We recommend that permanently installed survey pillars rather than tripods be used to support the surveying instruments. These pillars would reduce the time for setting up the instruments and would reduce inaccuracies.

The details of the proposed survey pillars are shown in Fig. 5. Four survey pillars are needed for datum reference points and from which the monuments will be surveyed for each epoch. They should be located on the abutments of the dam with a clear view to all monuments. They should be constructed of a 14-in.-diameter concrete pillar embedded at least 3 ft into competent bedrock and protrude 4 ft above the bedrock surface. A pillar plate on which the survey instrument will be mounted should be permanently installed in the top of the survey pillar.

Horizontal and vertical movements of the survey monuments will be monitored using the system described above. We propose to utilize observing procedures that will satisfy National Geodetic Survey 1st order network requirements. The angle observations will be performed using Wild Heerbrugg T2000 electronic theodolites or T3 Conventional theodolites with direct reading to 0.2 seconds of arc. Distance will be measured with a precision electronic distance measuring instrument (EDMI) utilizing infrared or laser wave lengths as a light source. It is anticipated that the surveying methods will yield accuracies of about 3-5 mm (0.01-0.015 ft).

We recommend that the dam sections at Stations 4+30, 5+95, and 7+80 be surveyed prior to installation of the inclinometers and survey monuments. The surveyed sections can be compared to the design slope geometry and can be used to help finalize the actual instrument locations.

#### 4. COST EVALUATION

##### 4.1 Slope Inclinator Installation

Estimated costs for slope inclinometer installation, including drilling, construction, and material costs, are summarized in Table 1. The cost items required for installation include building three gravel access roads to the proposed slope inclinometer locations, constructing three deadmen and hoist systems, constructing and moving a drilling platform to each slope inclinometer location, drilling a borehole in which to install the slope inclinometer casing, providing the slope inclinometer casing materials, and installing the slope inclinometer casing. Each item is divided into categories of labor, equipment, and material costs.

The ranges in unit costs shown in Table 1 for drilling the hole and installing the inclinometers are based on the range of unit costs provided by the drilling contractors we contacted. The unit cost for drilling the hole is based on the day rate for the drill rig and the rate of drilling estimated by the drilling contractors. The actual cost will depend on the actual rate of drilling and may be different from our estimate.

The estimated total cost for installing the slope inclinometers, not including A/E observation services, is \$104,000 to \$156,000. This range is approximate because it is difficult to predict the actual amount of equipment required for accessing and drilling the holes and the rate of drilling through rockfill. None of the drillers who provided cost estimates visited the site so their estimates are approximate. Also the estimate is based on the work not being performed during cold weather. Cold weather would result in additional drilling costs due to slower progress and increased standby time. The actual costs may, therefore, not be within the estimated range of total cost.

The estimated cost for A/E observation of the installation of the inclinometers is \$29,000 (see Table 2). Detailed cost breakdowns are presented in Appendix C. This estimated cost is based on the field work being completed within a 9-week period. The total estimated cost for installation of the inclinometers is \$133,000 to \$185,000.

##### 4.2 Survey Monument and Pillar Installation

Estimated costs for installation of 39 survey monuments and 4 survey pillars are summarized in Table 3. The cost

items required for installation of the monuments and pillars include drilling the holes and installation and are divided into labor, equipment, and material costs.

We estimate that about 1 week will be required to complete the installation of 39 monuments and about 1 week to complete the installation of 4 pillars. The installation should be performed by a surveying contractor.

The estimated total cost for installing the survey monuments and pillars is \$30,000. This is based on all work being completed within a 2-week period.

#### 4.3 Data Collection

The estimated cost for A/E services to monitor the inclinometers 13 times over a period of 1 year and to reduce, plot, and evaluate the data is \$33,000 (see Table 2). See Appendix C for detailed cost breakdowns. The 13 monitoring visits include an initial monitoring visit after the instruments are allowed to stabilize for 1 to 2 weeks after installation and monthly visits thereafter for 12 months.

The estimated cost for the surveying contractor to monitor the survey monuments for a period of 1 year and reduce, plot, and analyze the data is \$155,000 (see Table 4). This cost is based on a 4-man field crew performing a 5-day monitoring visit once after the monuments and pillars are allowed to stabilize for 1 to 2 weeks after installation and monthly thereafter for 12 months. It should be noted that this cost can be reduced substantially if the number of survey monuments is reduced and if the number of monitoring visits is reduced.

#### 4.4 Preliminary and Final Reports

The estimated cost for A/E services to prepare a preliminary report summarizing the inclinometer monitoring results after 6 months (7 monitoring visits) and a final report after 12 months (13 monitoring visits) is \$12,000 (see Table 2).

The estimated cost for the surveying contractor to prepare preliminary and final reports summarizing the survey monument monitoring results is \$9,000 (see Table 4).

TABLE 1 - ESTIMATE OF CONTRACTOR AND MATERIAL COSTS  
FOR SLOPE INCLINOMETER INSTALLATION  
Instrumentation Evaluation  
Ball Mountain Dam, Jamaica, VT

Page 1 of 3

Item	Unit	Estimated Quantity	Unit(1) Cost \$	Estimated Cost (6 Inclinometers, 675 ft Length of Borings)(1)
1. Access Road				
Materials				
Crushed Stone	cy	30	10	\$ 300
2. Platform				
Labor and Equipment				
Construct platform	man hrs	16	1,920	\$ 1,920
Move platform	man hrs	8	960	\$ 4,800
Materials				
Wood	ea	1	1,000	\$ 1,000
Hardware	ea	1	200	\$ 200
3. Deadmen and hoist	ea	3	4,000(2)	\$12,000
4. Dozer	Day	5	660	\$ 3,300

NOTES: See notes on page 3.

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TABLE 1 - ESTIMATE OF CONTRACTOR AND MATERIAL COSTS  
FOR SLOPE INCLINOMETER INSTALLATION  
Instrumentation Evaluation  
Ball Mountain Dam, Jamaica, VT

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Item	Unit	Estimated Quantity	Unit(1) Cost \$	Estimated Cost (6) Inclinometers, 675 ft Length of Borings (1)
5. Drilling Hole				
Labor and Equipment				
Mobilization-Demobilization	ea	1	3,000 to 10,000	\$ 3,000 to \$10,000
Drilling cased hole	ft	675	40-50(3)	\$27,000 to \$33,750
Move, setup	Day	1-2	2,000 to 4,000	\$ 2,000 to \$ 8,000
Standby	Day	3	2,000 to 4,000	\$ 6,000 to \$12,000
6. Slope Incliner				
Labor and Equipment				
Installation	Day	9	2,000 to 4,000	\$18,000 to 36,000

NOTE: See notes on page 3.

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TABLE 1 - ESTIMATE OF CONTRACTOR AND MATERIAL COSTS  
FOR SLOPE INCLINOMETER INSTALLATION  
Instrumentation Evaluation  
Ball Mountain Dam, Jamaica, VT

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Item	Unit	Estimated Quantity	Unit(1) Cost \$	Estimated Cost (6) Inclinometers, 675 ft Length of Borings)(1)
<b>Materials</b>				
Telescoping casing	ft	675	5.67	\$ 3,830
Telescoping couplings	ea	60	24.15	\$ 1,449
Caps	ea	12	2.78	\$ 34
Screws	ea	480	0.10	\$ 48
Shipping (air freight)	ea	1	500	\$ 500
Sand/peastone	cy	10	10	\$ 100
Steel cover	ea	6	100	\$ 600
Grout	-	-	-	\$ 60
			Subtotal	\$86,141 to
				\$129,891
			Add 20% Contingency	\$17,228 to
				<u>\$25,978</u>
			TOTAL	\$103,369 to
			SAY	\$155,869
				\$104,000 to
				\$156,000

- NOTES: (1) Ranges shown are based on approximate range of estimated costs from drilling contractors contacted by GEI.  
(2) The cost for the deadmen and hoist will depend on the type of system the contractor has available and is difficult to estimate. A unit cost of \$4,000 has been assumed.  
(3) This cost is based on the day rate for the drill rig and the estimated rate of drilling per day.  
(4) See Table 3 for A/E observation costs for installation of slope inclinometers.

TABLE 2 - ESTIMATED COSTS FOR A/E SERVICES  
Instrumentation Evaluation  
Ball Mountain Dam, Jamaica, VT

	Manpower	Estimated Costs Expenses	Total	Say
1. Observe inclinometer installation (based on 9-week duration)	25,700	\$3,300	\$29,000	\$29,000
2. Monitor inclinometers, reduce data, and evaluate readings (based on 13 monitor- ing visits)	30,500	\$2,400	\$32,900	\$33,000
3. Prepare preliminary report after 7 visits and final report after 13 visits	12,200	\$ 200	\$12,400	\$12,000
			<u>\$74,300</u>	<u>\$74,000</u>

NOTE: See Appendix C for breakdown of costs.

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TABLE 3 - COST ESTIMATE FOR SURVEY MONUMENT AND  
SURVEY PILLAR INSTALLATION  
Instrumentation Evaluation  
Ball Mountain Dam, Jamaica, VT

Page 1 of 2

Item	Unit	Estimated Quantity	Unit Cost \$	Estimated Cost for 39 Monuments
<b>SURVEY MONUMENT</b>				
1. Drilling Holes				
Labor and equipment				
Jackhammer drilling	Monument	39	60	\$ 2,340
Drilling equipment rental	Day	5	300	1,500
2. Installation of Monuments				
Labor and equipment (performed by surveying contractor)	-	-	-	\$ 5,300
Materials - including target, target pedestal, pipe, rebar, and grout	Monument	39	220	\$ 8,580
<b>SURVEY PILLAR</b>				
1. Drilling Holes				
Labor and equipment				
Jackhammer drilling	Pillar	4	240	\$ 960
Drilling equipment rental	Day	4	300	1,200
				<u>Estimated Cost for Four Pillars</u>

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TABLE 3 - COST ESTIMATE FOR SURVEY MONUMENT AND  
SURVEY PILLAR INSTALLATION  
Instrumentation Evaluation  
Ball Mountain Dam, Jamaica, VT

Page 2 of 2

Item	Unit	Estimated Quantity	Unit Cost \$	Estimated Cost for Four Pillars
SURVEY PILLAR (continued)				
2. Installation of Pillars				
Labor and Equipment (performed by surveying contractor)	-	-	-	\$ 5,300
Materials - including base plate, centering socket, levels, target insert, concrete, and rebar	Pillar	4	410	\$ 1,640
Subtotal				\$26,820
Add 10% Contingency				<u>2,682</u>
TOTAL				\$29,502
SAY				\$30,000

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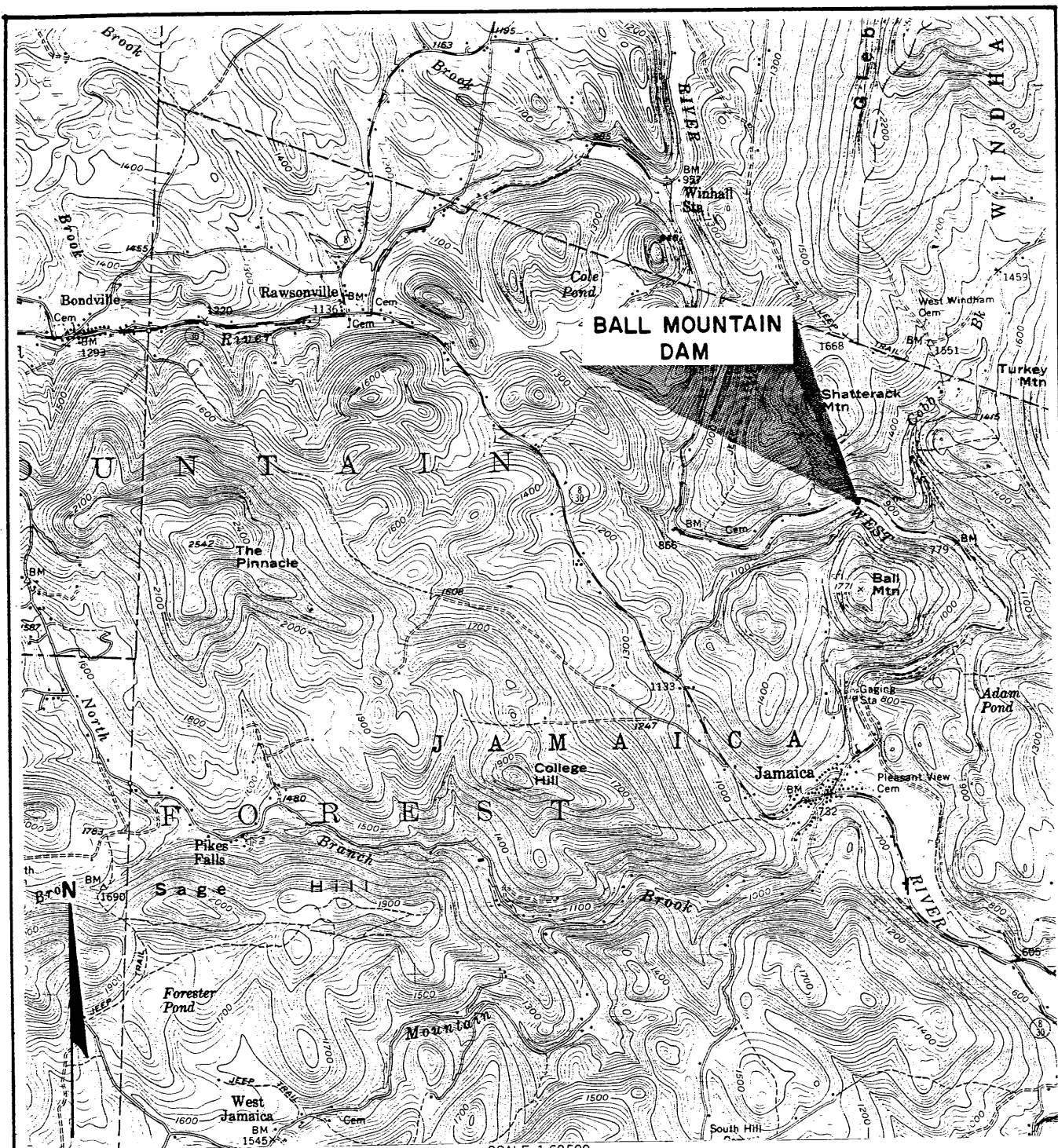
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TABLE 4 - ESTIMATED COSTS FOR SURVEYING CONTRACTOR  
 SURVEY MONUMENT MONITORING AND REPORT  
 Instrumentation Evaluation  
 Ball Mountain Dam, Jamaica, VT

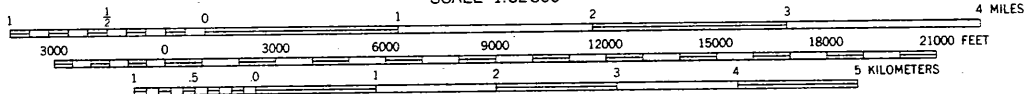
<u>Task</u>	<u>Estimated Costs</u>		
	<u>Manpower</u>	<u>Expenses</u>	<u>Total</u>
1. Monitor survey monuments, process and analyze data, send summary to A/E (based on 13 trips)	143,000	\$12,000	\$155,000
2. Prepare preliminary report after 7 visits and final report after 13 visits	8,500	\$ 500	\$ 9,000
			<hr/> \$164,000

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SCALE 1:62500



CONTOUR INTERVAL 20 FEET  
DATUM IS MEAN SEA LEVEL

Reproduced from US Geological Survey topographic map for the Londonderry, VT 15 minute quadrangle.

U. S. Corps of Engineers  
Waltham, MA

Instrumentation Evaluation  
Ball Mountain Dam  
Jamaica, VT

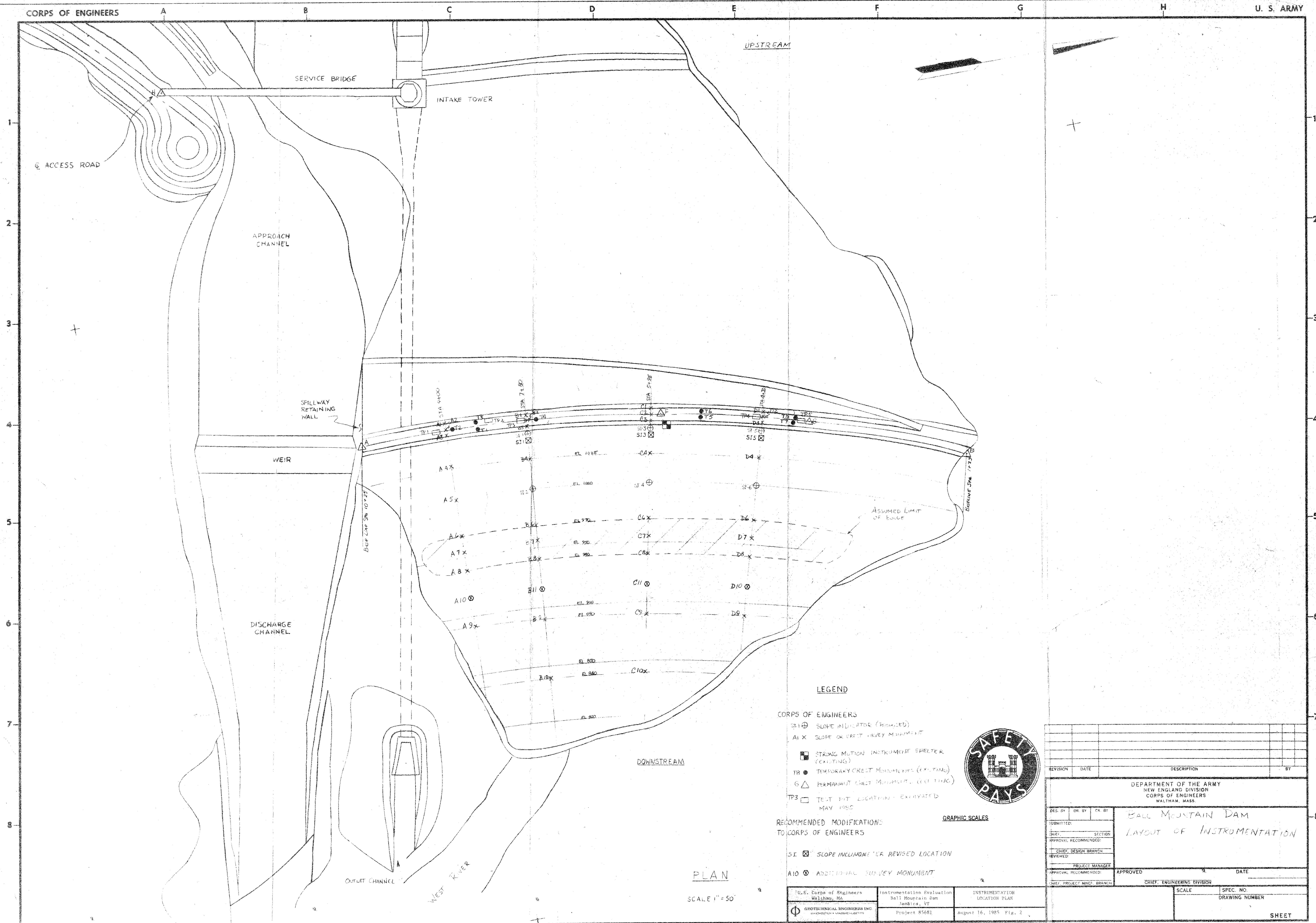
PROJECT SITE  
LOCATION PLAN

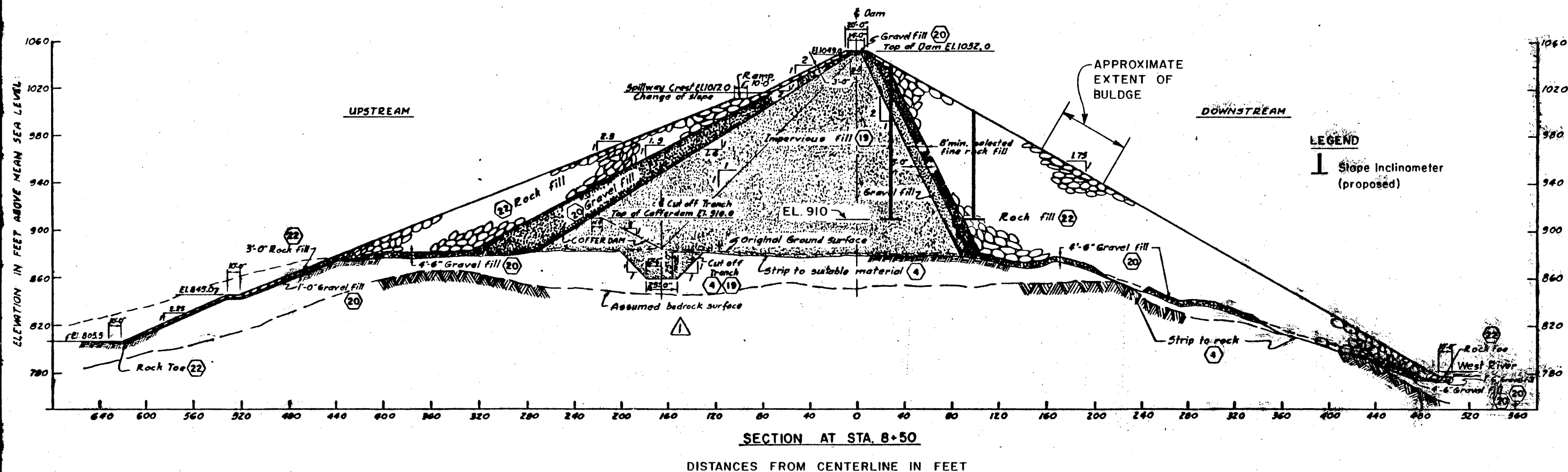


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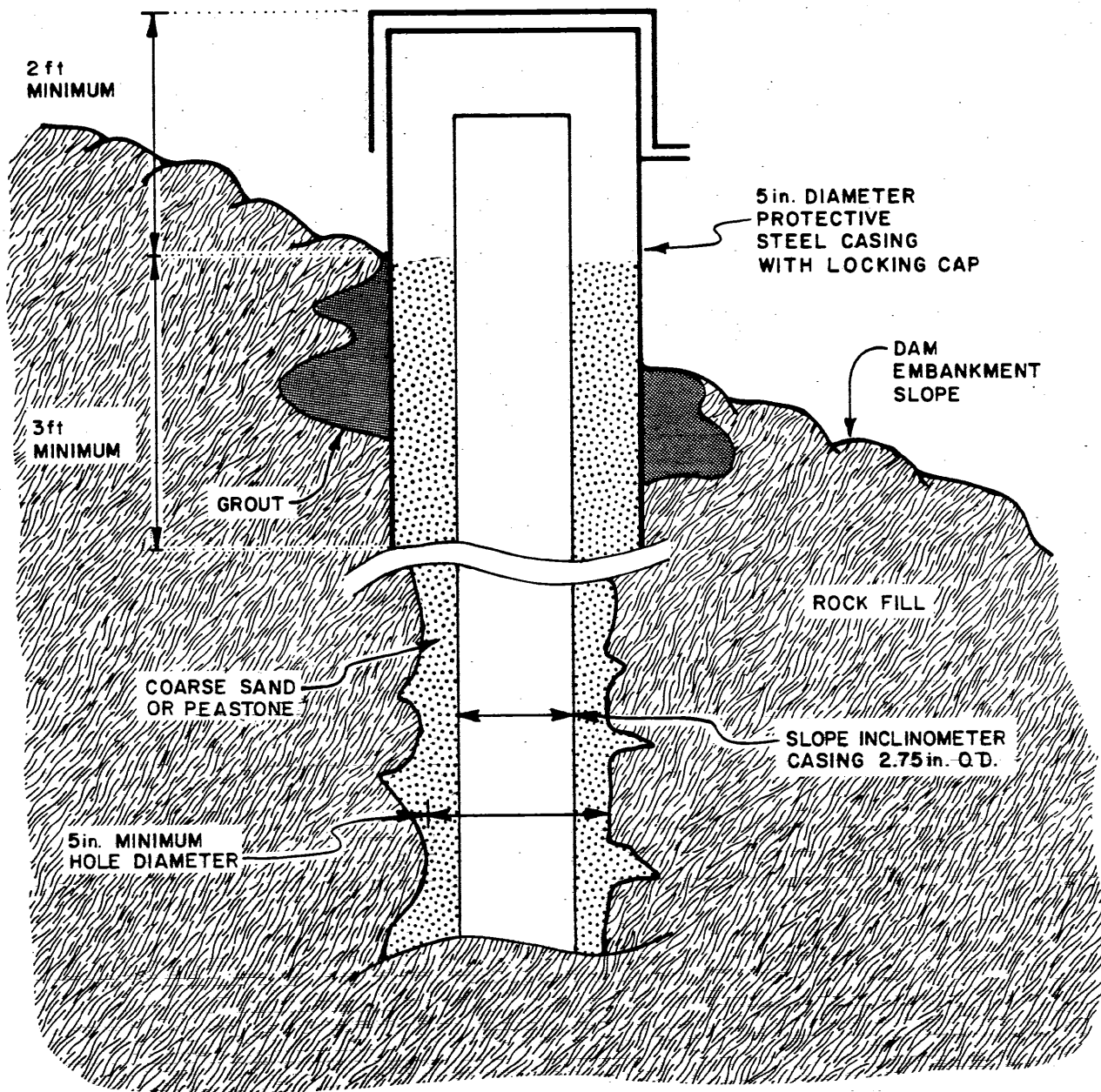
August 16, 1985 Fig. 1





Base drawing taken from NED-COE drawing CT-1-4174, Feb. 1957  
 Ball Mountain Dam, Embankment Sections and Profiles

U.S. Corps of Engineers Waltham, MA	Instrumentation Evaluation Ball Mountain Dam Jamaica, VT	SLOPE INCLINOMETER LOCATION SECTION
 GEOTECHNICAL ENGINEERS INC. WINCHESTER • MASSACHUSETTS	Project 85681	August 16, 1985 Fig. 3



NOT TO SCALE

U.S. Corps of Engineers  
Waltham, MA

Instrumentation Evaluation  
Ball Mountain Dam  
Jamaica, VT

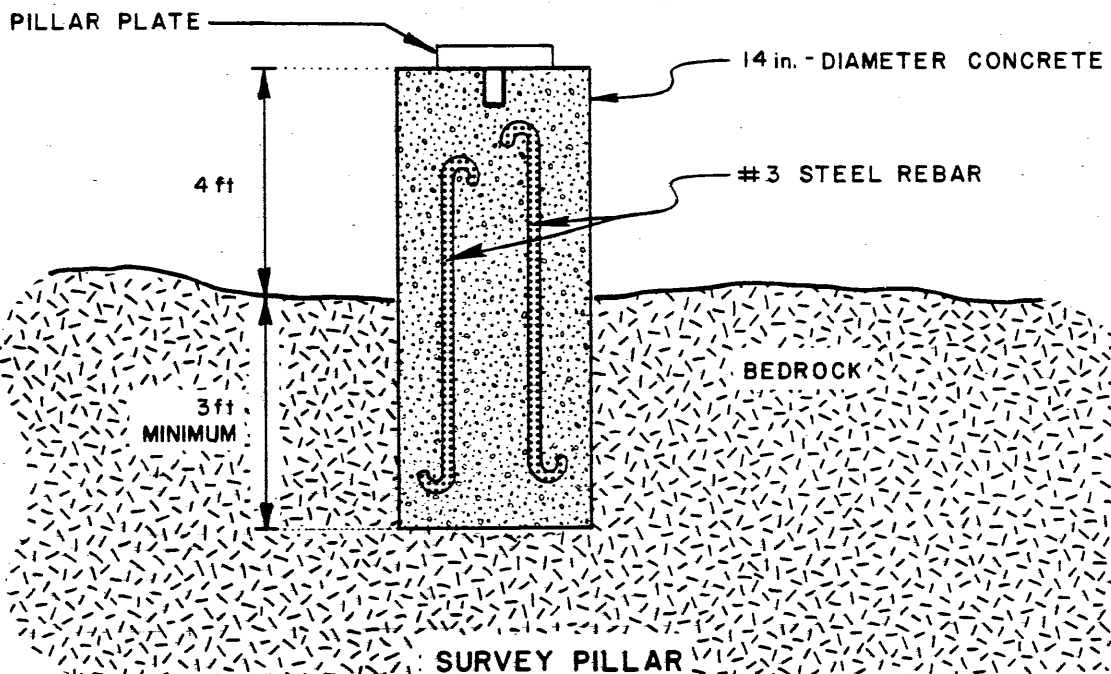
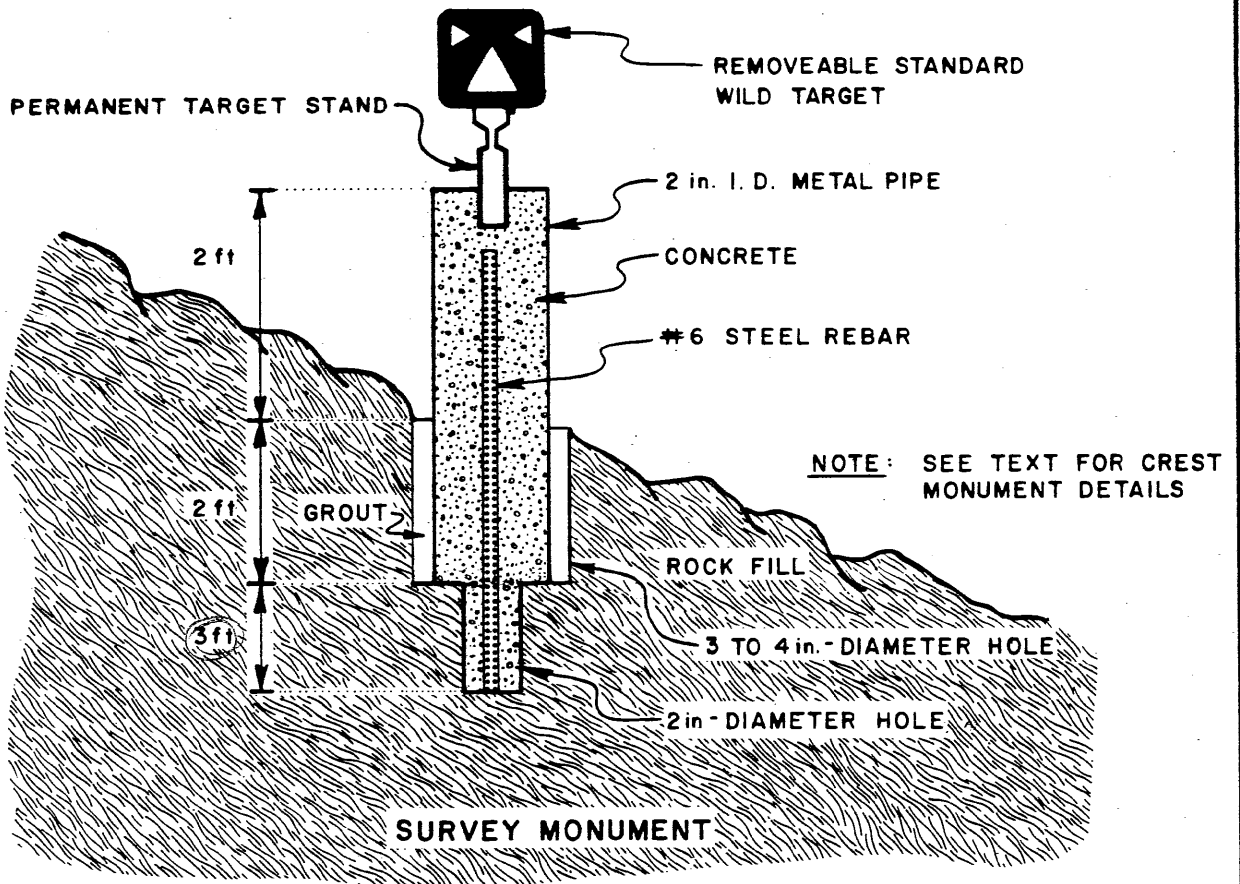
SLOPE INCLINOMETER  
INSTALLATION DETAILS



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SURVEY MONUMENT  
AND PILLAR INSTALLA-  
TION DETAILS



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## APPENDIX A

### SPECIFICATIONS FOR SLOPE INCLINOMETER CASING

- A.1 General
- A.2 Materials
- A.3 Installation

## SPECIFICATIONS FOR SLOPE INCLINOMETER CASING

### A.1 General

The work to be performed under this item shall consist of installing slope inclinometer casings. The casing and couplings will be provided by the Engineer.

The work to be performed under this item includes the furnishing of all materials, labor, equipment, and performing all operations needed to install, and make operable, the instrumentation described herein. Materials and equipment not shown, but which are required to provide a satisfactory and complete installation, shall be included under this item. The inclinometer casing shall be installed as herein specified and as instructed by the Engineer. All materials, equipment, and methods proposed to be used by the Contractor shall be subject to approval by the Engineer before the work is begun. Installation details are shown in Fig. 4 in the main text.

### A.2 Materials

1. The inclinometer casing and accessories shall be provided by the Engineer and shall be ABS Plastic Telescoping Casing having an outside diameter of 2.75 in. and an inside diameter of 2.32 in. The casing shall be installed in 10-ft lengths. The couplings shall be telescoping couplings of ABS plastic which permit an initial gap between casing lengths of at least 6 in. A plastic bottom and top plug shall be provided. The Contractor shall provide a protective casing with locking cap having a minimum diameter of 5 in. and a length of 5 ft for each inclinometer hole.
2. Coarse sand or peastone may be used to fill the annulus between the slope inclinometer casing and borehole and shall conform to the following gradation. The sand shall be a coarse sand with at least 80 percent by weight having a range in grain size from 0.08 to 0.2 in. The peastone shall be a fine gravel with at least 80 percent by weight having a range in grain size from 0.2 to 0.75 in.

### A.3 Installation

1. Advance the boring to the specified depth using down-hole hammer drilling techniques approved by the Engineer. The boring shall be cased the full depth of the boring and the casing shall have a minimum I.D. of 5 in. Drilling mud should not be needed.
2. Flush the borehole with compressed air until clean of cuttings. Foam flushing may be required for depths greater than 50 ft.
3. Place 6 to 12 in. of coarse sand or peastone in a layer at the bottom of the borehole to serve as a base for the inclinometer casing.
4. Cap the bottom of the first piece of slope inclinometer casing, attach a coupling, and lower it down the borehole.

Add lengths of inclinometer casing (the telescoping couplings should be attached in the extended position) until the desired depth is reached. Make sure that the grooves are aligned as per the requirements of the Engineer.

5. Do not cut off the top piece of slope inclinometer casing. It is preferable that the casing lengths be arranged so that a stickup of 1 to 2 ft extends above the ground surface.
6. Backfill the annulus between the inclinometer casing and the boring with coarse sand or peastone in intervals as the steel casing is withdrawn (see Fig. 4).

NOTE: The backfill should be tamped in layers of 2 ft or less with an approved tamping device as directed so as not to slide the inclinometer casing together at the couplings. Withdraw the boring casing in intervals as specified after the placement of the backfill but before tamping.

7. Install the protective steel casing with locking cap with the top of this casing about 2 in. above the top of the inclinometer casing. Grout the steel casing into the rock embankment with at least 2 ft extending above and at least 3 ft extending below the embankment surface (see Fig. 4).

## APPENDIX B

### SPECIFICATIONS FOR SURVEY MONUMENTS AND SURVEY PILLARS

- B.1 General
- B.2 Materials
- B.3 Installation

## SPECIFICATIONS FOR SURVEY MONUMENTS AND PILLARS

### B.1 General

The work to be performed under this item shall consist of installing survey monuments in the dam embankment and crest and installing survey pillars in the dam abutments.

The work to be performed under this item includes the furnishing of all materials, labor, equipment, and performing all operations needed to install and make operable the instrumentation described herein. Materials and equipment not shown but which are required to provide a satisfactory and complete installation shall be included under this item. The survey monuments and pillars shall be installed as herein specified and as instructed by the Engineer. All materials, equipment, and methods proposed to be used by the Contractor shall be subject to approval by the Engineer before the work is begun. Installation details are shown in Fig. 5 in the main text.

### B.2 Materials

#### a. Survey Monument

The steel pipe for slope and crest monuments shall be 4 ft long and have an inside diameter of 2 in. The rebar shall be a standard #6 steel reinforcing bar. Concrete aggregate shall consist of quartz, limestone, or granite and have a maximum diameter of 1/4 in. The grout shall be a nonshrink type. The permanent target stand and sleeve will be provided by the Engineer. The steel protective casing and hinging cap for crest monuments shall be at least 1.5 ft long and minimum 3 in. diameter.

#### b. Survey Pillar

The concrete shall have aggregate consisting of quartz, limestone, or granite. The rebar shall be a standard #3 steel reinforcing bar. The pillar plate will be provided by the Engineer.

### B.3 Installation

#### a. Slope Survey Monument

(1) Make a 5-ft-deep vertical borehole in the rock-fill embankment with a jackhammer drill. The upper

2 ft shall be a 3- to 4-in.-diameter hole, and the lower 3 ft shall be a 2-in.-diameter hole.

(2) Install the 4-ft-long steel pipe 2 ft into the borehole. Fill the pipe with concrete and insert the rebar to the bottom of the 5-ft hole along the center axis of the pipe. Grout the annulus between the pipe and the borehole in the rockfill.

(3) Install the permanent target stand into the top of the concrete filled pipe.

b. Crest Survey Monument

(1) Make a 5-ft-deep, 3- to 4-in.-diameter vertical borehole in the crest.

(2) Install the 4-ft-long steel pipe 4.5 ft into the borehole. Fill the pipe with concrete and insert the 4.5-ft-long rebar to the bottom of the 5-ft hole along the center axis of the pipe. Grout the annulus between the pipe and the borehole.

(3) Install a threaded sleeve into the top of the concrete filled pipe for the target stand.

(4) Install and grout the protective steel casing with hinging cap such that the top is about 1 in. below the crest surface.

c. Survey Pillar

(1) Line drill a series of vertical boreholes into competent bedrock with a jackhammer drill such that a 14-in.-diameter minimum 3-ft-deep hole can be excavated.

(2) Install two #3 steel reinforcing bars at the locations shown in Fig. 5. Form the section of the pillar which extends 4 ft above the bedrock surface.

(3) Fill the hole and form with concrete.

(4) Install the permanent pillar plate into the concrete at the top of the pillar.

## APPENDIX C

### ESTIMATED COSTS

- Table C1 - Man-Hour Breakdown by Personnel Category  
Slope Inclinator Installation and Monitoring
- Table C2 - A/E Cost Breakdown  
Slope Inclinator Installation and Monitoring
- Table C3 - Breakdown of A/E Expenses  
Slope Inclinator Installation and Monitoring

TABLE C1 - MAN-HOUR BREAKDOWN BY PERSONNEL CATEGORY  
SLOPE INCLINOMETER INSTALLATION AND MONITORING  
Instrumentation Evaluation  
Ball Mountain Dam, Jamaica, VT

	Principal	Project Manager	Geotechnical Engineer	Drafts- person	Technical Typist
1. Prepare for field work and order inclinometer materials	8	24	32	-	-
2. Observe inclinometer in- stallation (based on 9 weeks of work)	18	66	414	-	-
3. Monitor inclinometers, reduce data, and evaluate readings (based on 13 monitoring visits	39	104	520	-	-
4. Prepare preliminary report after 7 visits and final report after 13 visits	16	48	128	48	48
5. Two coordination meetings at NED-CE	4	8	-	-	-
TOTAL	85	250	1,094	48	48

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TABLE C2 - A/E COST BREAKDOWN  
SLOPE INCLINOMETER INSTALLA-  
TION AND MONITORING  
Instrumentation Evaluation  
Ball Mountain Dam, Jamaica, VT

(1) Direct Labor Costs (by personnel categories)

<u>Category</u>	<u>Hours</u>	<u>Average Wage Rate</u>	<u>Category Total</u>
Principal	85	\$22.50	\$ 1,912.50
Project Manager	250	19.00	4,750.00
Engineer (Geotechnical)	1,094	15.00	16,410.00
Draftsperson	48	10.00	480.00
Technical Typist	48	7.50	<u>360.00</u>
Subtotal, Direct Labor			\$23,912.50

(2) Overhead on Direct Labor (29.2% of Direct Labor) \$ 6,982.45

(3) Materials, Supplies --

(4) Gen. & Adm. Overhead (128.25% of Direct Labor) 30,667.78

(5) Travel (See Table C3 for breakdown) 4,964.50

(6) Other Costs (See Table C3 for breakdown) 400.00

Total Costs \$66,927.23

(7) Profit (11%) \$ 7,362.00

Total Fee \$74,289.23

Say \$74,000.00

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TABLE C3 - BREAKDOWN OF A/E EXPENSES  
SLOPE INCLINOMETER INSTALLA-  
TION AND MONITORING  
Instrumentation Evaluation  
Ball Mountain Dam, Jamaica, VT

1. Travel

a. Observe inclinometer installation

(1) Full-time observation by engineer	
Per diem 9 weeks x 5 days/wk x \$50/day	\$2,250.00
Mileage 9 trips x 300 mi/trip x \$0.205/mi	553.50
(2) Site visit by project manager	
Mileage 300 mi x \$0.205/mi	61.50

b. Monitor inclinometers

Per diem 13 trips x 2 days/trip x \$50/day	1,300.00
Mileage 13 trips x 300 mi/trip x \$0.205/mi	<u>799.50</u>

Total Travel	\$4,964.50
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2. Other Costs

a. Telephone

During observation of installations	\$ 100.00
During monitoring	100.00

b. Report Reproduction

200.00

Total Other Costs	\$ 400.00
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Total Expenses	\$5,364.50
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